Brain Segmentation using Support Vector Machine: Diagnostic Intelligence Approach

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ABSTRACT

In the quantitative analysis of brain tissues, in magnetic resonance (MR) brain images, segmentation is the preliminary step. In this paper first we analyzed and compared various techniques used for Brain Image segmentation. Further it introduces an automatic model based technique for brain tissue segmentation from cerebral magnetic resonance (MR) images by using support vector machine (SVM) based classifier. A new and powerful kind of supervised machine learning with high generalization characteristics, is employed SVM. An iterative process is used for brain segmentation, so that the probabilistic maps of brain tissues will be updated at any iteration.

Keywords*:* Magnetic Resonance Image, Image Segmentation, Support Vector Machine (SVM), Least Square Support, Vector Machine (LS-SVM).

1. INTRODUCTION

Image segmentation is often required as a preliminary and indispensable stage in the computer aided medical image process, particularly during the clinical analysis of magnetic resonance (MR) brain image. MR brain image segmentation has wide applications. It can be used in quantitative analysis of tissue volumes in medical diagnosis [7]. It also enables visualization of tissue structures in three dimensions, which will benefit physicians greatly not only in diagnosis but also in treatment planning. Detection of internal structure in brain MRI is widely used to diagnose several brain diseases such as epilepsy, multiple sclerosis, schizophrenia and alcoholism.

During the image processing, edge information is the main clue in image segmentation. But, unfortunately, it can't get a better result in analysis the content of images without combining other information. So, many researchers combine edge information with some other methods to improve the effect of segmentation [1] [2] [3]. Quantitative studies of anatomical brain tissue such as white matter (WM), grey matter (GM) and cerebrospinal fluid (CSF) usually depend on segmentation of various structures of the brain that have distinctive structural or functional properties [4]. Hence for comprehensive brain analysis a reliable, accurate and automated segmentation of brain MR images is considered as a prerequisite.

MRI Brain segmentation precisely is a prerequisite for applied research as follows:

1. To detect the different pathological conditions on the substance of the Brain.

2. Establish the radiotherapy and radiotherapy plan.

3. Surgical planning and simulation.

4. Brain structure of the 3D visualization and quantitative measurement.

5. Research on brain development and aging mechanism.

6. Research on functional brain.

Due to system noises, excessive or lack of exposal, or relatively movement, it's very difficult to segment MRI accurately without pre-processing. Most proposed image segmentation techniques fall into the categories of characteristic feature threshold or clustering and edge detection [5][6].

The paper is organized in following manner. Section II discusses about the history of MRI image segmentation. Section III has detail view of few successful modern techniques. Section IV compares theses techniques based on their performance. Section V focuses on the MRI segmentation using Support Vector Machine (SVM) technique. Section VI concludes the work.

2. LITERATURE SURVEY

Magnetic resonance imaging is an important diagnosis imaging technique used for early detection of abnormal changes in tissues and organ [8]. Major areas of application include the automatic and semiautomatic delineation of areas to be treated prior to radio-surgery, and the delineation of tumors before and after surgeries for response assessment [9]. However manual segmentation of these kinds of images is a time consuming job and human mistakes are inevitable.

During last few years several studies on the automatic recognition of normal tissue in the brain and its surrounding structures is carried out. Many image processing techniques have been proposed for brain MRI segmentation, in which threshold, region-growing, and clustering was major used. Since distribution of tissue intensities in brain image is very complex, it lead to difficulties of threshold determination. Therefore threshold methods are generally restrictive and have to combine with other methods [5]. Region growing extends threshold by combining it with connectivity conditions or region homogeneity criteria. Successful methods require precise anatomical information to locate single or multiple seed pixels for each region and together with their associated homogeneity [6]. The most popular Fuzzy c-means (FCM) clustering algorithm, an unsupervised clustering technique, has been successfully used for image segmentation [4, 5]. Compared with hard c-means algorithm [6], FCM is able to preserve more information from the original image. The pixels on an image are highly correlated, i.e. the pixels in the immediate neighborhood possess nearly the same feature data. Therefore, the spatial relationship of neighboring pixels is an important characteristic that can be of great aid in imaging segmentation.

However, the standard FCM does not take into account spatial information, which makes it very sensitive to noise.

3. MODERN SEGMENTATION TECHNIQUES

In [10] a novel method for segmenting brain tissues in MR images based on k-means objective function combined with genetic algorithm is presented. The method includes three main steps: (1) removal of non-brain tissues, (2) bias correction, and (3) tissue classification. Since genetic algorithm has advantages in searching the global optimum, the segmentation method in this paper is more accurate and its speed is also high. The genetic algorithm usually includes the following four steps.

1) Individual Coding and Initialization of Population

2) Design of Fitness Function: Fitness function is used to quantify the adaptive ability of each individual during evolution course. The fitness value is larger, the adaptive ability of the individual is stronger and the probability that the individual can be kept to the next generation is larger.

3) Design of Genetic Operation: The evolution from one generation to the next.

4) Controlling Parameters Set: before genetic algorithm is executed, there are four controlling parameters should be set. They are 'Pn', 'Gn', 'Pc', and 'Pm'.

Pn is the population number; it was used to control the size of population.

Gn is the generation number, it was used to control the time when genetic algorithm stops

Pc is the probability of crossover; it was used to control the number of generating new individuals at the prophase of evolution

Pm is the probability of mutation; it was used to control the number of generating new individuals at the anaphase of evolution

Segmentation of Brain MR Images using an Ant Colony Optimization Algorithm is described in [11] which is a segmentation method for brain MR images using an ant colony optimization (ACO) algorithm. This is a relatively new meta-heuristic algorithm and a successful paradigm of

all the algorithms which take advantage of the insect's behavior. In this paper, in order to effectively obtain optimal threshold, a better method that uses ant colony optimization algorithm is proposed. The proposed method is defined by the 'food' for object segmentation in image. The food is memorized by ants during image segmentation process. Then, the ants deposit pheromone on the pixels, which will affect the motion of the ants. At each iteration step, the ants will change their position in the image according to the transition rules.

In Masking based Segmentation of Diseased MRI [12], the image is segregated based on levels of intensity, considering that diseased portion of the MRI image will have a different intensity value with that of a non diseased multimodal MRI image. Entropy maximization technique is used to get the range of gray level of diseased cells of MRI image. The range is optimized using particle swarm optimization (PSO) algorithm and further fine tuned using the concept of variable mask in which the mask is incrementally applied on the region of interest. Depending on the similarity of the neighborhood pixels the mask is incremented.

In [13] an automatic model based technique for brain tissue segmentation from cerebral magnetic resonance (MR) images is presented. In this paper, support vector machine (SVM) based classifier, as a new and powerful kind of supervised machine learning with high generalization characteristics, is employed. Here, least-square SVM (LSSVM)

in conjunction with brain probabilistic atlas as a priori information is applied to obtain class probabilities for three tissues of cerebrospinal fluid (CSF), white matter (WM) and grey matter (GM). The entire process of brain segmentation is performed in an iterative procedure, so that the probabilistic maps of brain tissues will be updated at any iteration. The quantitative and qualitative results indicate excellent performance of the applied method.

4. COMPARATIVE STUDY

The GA method operates slice by slice via three main steps: (1) the non-brain tissues are removed from the original images using level set method, (2) the bias in the images which is caused by the in-homogeneity in the magnetic field is corrected by statistic method, and (3) the brain tissues are classified by k-means objective function combined genetic algorithm [10]. The performance of the segmentation method was evaluated by the comparison with the fuzzy c-means (FCM) algorithm which is commonly used in segmentation of MR brain images. The accuracy of the proposed method is 3.21% higher than that of FCM algorithm. The time consumed in the proposed method is 0.596 second per image.

It is proved from the experimental result that, using an Ant Colony Optimization Algorithm, to process image segmentation, not only efficiently segments the target and the background, but also provides the segments thin parts more effectively, and it obtains satisfactory effect [11]. Ant-colony methods outperforms as number of iterations are increased form 100 to 200. Also the results are more reliable as compared to genetic algorithm and the old Ant-colony optimization algorithm. It is observed from the experiments for the MR images, the segmentation result using the proposed ant colony optimization algorithm is more robust than the other method

Masking based Segmentation of Diseased MRI Images [12] is used for multimodal MRI images rather than bimodal. Due to the usage of low pass filters of variable sized mask, distinction between diseased and non diseased portions of an MRI image is more vivid. The algorithm is tested on various diseased MRI images showed that small diseased objects are successfully extracted irrespective of the complexity of the background and difference in intensity levels and class sizes.

5. SVM TECHNIUQE

As least square SVM (LSSVM) with radial basis function (RBF) kernel is readily found with excellent generalization performance and low computational cost [13], it is employed to produce the class probabilities. Here, a method is used to map the LS-SVM outputs into posterior probabilities by applying a sigmoid function whose parameters are estimated from the training process. Integrating prior knowledge obtained from atlases into LS-SVM leads to improving the classification accuracy.

Principal of SVM

Support Vector Machines as a set of supervised learning methods are used for both classification and regression problems based on Statistical Learning Theory (SLT) [14]. SVM is designed in the first place for solving the binary problems. Recently, methods are introduced to generalize to problem into multi-classification problem. The basic idea behind SVM is to construct an optimal separating hyper-plane, which tries to maximize the margin (maximum distance to the closest data point) between feature vectors belonging to different classes, and minimize the classification error.

The theory of brain segmentation presented in [14] is based on using LS-SVM learning method. In this technique, LS-SVM regression is used for the application of function estimation. Here, we aim to estimate the class probability of each voxel based on using a supervised learning method. The training samples for the learning machine are chosen using a priori information available in atlas.

The entire segmentation process can be summarized in the following steps:

1) Preprocessing: Registration of probabilistic atlases with input data and skull-stripping should be performed before the segmentation process.

2) Sampling and feature extraction: Discretizing atlases and then Sampling from each class, location and intensity of voxels can be chosen as the elements of feature vector.

3) Segmentation: Training the LS-SVM learning method, exploiting sigmoid function and updating the probabilistic atlases are the key parts of segmentation process.

4) Return to the first step to start the next iteration.

5) Exit the loop after receiving desirable results and discretizing the probabilistic outputs.

Since LS-SVM learning method provide a good generalization over different types of input data and the process is performed iteratively, this method offers an acceptable accuracy of segmentation.

6. CONCLUSION

In this paper, the use of a learning method technique for classifying three brain tissues, WM, GM and CSF, was investigated. In this comparative study, we considered novel methods used for MRI image segmentation. The ant colony method based on meta-heuristic algorithm is observed to be comparatively reliable than genetic algorithm and old ant colony technique. The masking based method found to produce more accurate results for multimodal MRI images as compared to other techniques.

The iterative LS-SVM-based method was employed to produce class probability of each tissue based on the prior probability knowledge available in atlases. Comparing to other complicated atlas-based and learning based methods, this method gives an appropriate condition of brief feature vector and lower computational and time complexity. Hence LS-SVM-based method is observed to fit for the most complicated MRI images.

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